SCIENCE

FRIDAY, DECEMBER 31, 1915

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE FRUITS, PROSPECTS AND LESSONS OF RECENT BIOLOGICAL SCIENCE[1]

THE general welfare of mankind has been wonderfully promoted during the past 150 years by the rapid progress of chemical, physical, and biological science. In the early third of that period, physics and chemistry and their applications seem to have played the most active parts in promoting human welfare, although pure botany and zoology enlisted many devoted workers, and made great advances; but during the past 100 years it is biological science that has contributed most to the well-being of humanity. The new methods of transportation and of manufacturing by the aid of machinery with steam as motive power were products of applied physics. So were the great works of civil and mechanical engineering. The improved agriculture of the last half of the nineteenth century was partly due to new tools and machinery, and partly to new applications of chemical knowledge. Latterly biological science has helped the farmer very much to raise better crops and animals, and to protect his products from vegetable and animal pests.

While the industrial and social changes, which applied physics and chemistry made possible, unquestionably improved the general condition of mankind as regards bodily comfort, security against natural catastrophes, longevity, and an increased sense of mutual support and community interest through the vast improvement in the means of communication, these changes

[1] Address of the retiring president of the American Association for the Advancement of Science, given at the Columbus meeting, December 27, 1915.

have all been *indirect* influences on human well-being and happiness, and with the good they brought much evil was mixed. Thus, the factory system, the congestion of population, and the noise and turmoil of city life are grave evils accompanying the advantages which applied physics and chemistry have created and diffused. The fruits of the biological sciences—botany, zoology, physiology and biochemistry, applied to curative medicine and surgery and to preventive medicine and sanitation—have been *direct* contributions to human welfare; because they have provided defenses against disease, premature death, and individual and family distress and suffering. The beneficent applications of biological science, unlike most of the large results of applied chemistry and physics, take effect in the field of human affections and family experiences, make life less anxious and more enjoyable for multitudes of human beings, mitigate or abolish ancient agonies and dreads of the race, and promise for it a happier future.

The career of Pasteur illustrates admirably the passing of the center of beneficent scientific research from chemistry and physics to biological science. Pasteur's first researches were crystallographic; whence he passed to the study of molecular dissymmetry, the material of his researches being, however, organic. He was first professor of physics and then professor of chemistry. His interest in certain tartrates led him naturally, though partly by accident, to a study of fermentation. His zealous discharge of his duties as Dean of a Faculty of Sciences at Lille, a manufacturing center, led to his study of beet-root juice, fermented in order to produce alcohol. Thereafter Pasteur's researches were biological, although he had had no training as either naturalist or physician. He began at the foundation by disproving the doctrine of spontaneous generation. One of his earliest conclusions was that "gases, fluids, electricity, magnetism, ozone, things known or things occult, there is nothing in the air that is conditional to life except the germs it carries." Of his earliest results from experiments on admitting pure air to flasks containing putrescible infusions he wrote:

> It seems to me that it can be affirmed that the dusts suspended in atmospheric air are the exclusive origin, the necessary condition of life in infusions;

and in the same paper he made the pregnant remark:

> What would be most desirable would be to push those studies far enough to prepare the road for serious research into the region of various diseases.

He lived to push his studies into the causes of the silk-worm disease, of a cholera which came from Egypt into France, of the plant diseases affecting the manufacture of wine and of beer, of the splenic fever, of the chicken-cholera, and of rabies; and he and his followers invented successful treatment for those diseases, and for the treatment of typhoid fever and diphtheria. The germ and parasite theory of disease led the way in serum therapy, and established both the philosophy and the practise of the new medicine and surgery of the past thirty-five years. Starting with a sound knowledge of chemistry and physics, and having early acquired a habit of utmost accuracy in observing and reasoning, Pasteur passed over into biological science by the time he was thirty-two years of age, and became the most suggestive and productive inventor and promoter in applied biology that has ever lived. His career illustrates conspicuously the general truth that the sciences most serviceable to mankind during the past sixty years have been the biological sciences. In a letter to his father in

1860, when his inquiries were opening new vistas in physiology, Pasteur wrote:

> God grant that by my persevering labors I may bring a little stone to the frail and ill-assured edifice of our knowledge of those deep mysteries of life and death, where all our intellects have so lamentably failed.

That prayer was granted.

Let us review in a summary way the fruits of applied biological science since the nineteenth century opened.

The first invention, vaccination against smallpox, long antedated the later studies of germs, parasites, the routes of disease from one human being to another through insects and other animals, and the theory and practise of immunity. Vaccination, the invention of a country doctor who practised in a dairy district, was a momentous discovery in immunity from a fatal and disfiguring disease which was frequently epidemic, the immunity being procured by causing in the human body another disease very seldom fatal and not at all disfiguring. The favorable reception and rapid application of Jenner's discovery were due to the fact that many persons at that time protected themselves against the frequent and terrible epidemics of smallpox by being inoculated with smallpox itself. So soon as it was proved that cowpox gave immunity in almost all cases against smallpox, inoculation with cowpox came rapidly into use; because inoculated cowpox proved to be, as one of Jenner's contemporaries remarked, "a pleasanter, shorter, and infinitely more safe disease than inoculated smallpox." The relief of civilized mankind from the terrible recurrent epidemics of smallpox is one of the greatest benefits that the profession of medicine has conferred on the human race.

From biological studies largely on microscopic organisms—protozoa, bacteria, and parasitic growths—the means of communication from one human being to another or from an animal to man of dysentery, cholera, typhoid fever, typhus fever, puerperal fever, bubonic plague, diphtheria, tuberculosis, cerebro-spinal meningitis, syphilis, gonorrhoea, sleeping sickness, yellow fever, malaria, and hookworm disease have all been brought to light. Means of preventing or restricting the spread of these diseases—with the exception of cerebro-spinal meningitis—have been invented, and for most of them improved methods of treatment have been devised. Much has also been learnt about infantile paralysis, and something about cancer. The whole subject of toxins and anti-toxins has been developed with wonderfully beneficent results.

It is really impossible to describe or appreciate the alleviations and preventions of human misery included in this list of the fruits of applied biological science. Some of the diseases mentioned were within a few years familiar household terrors in the most civilized countries, others from time to time destroyed in recurring epidemics large portions of the population in many parts of the world. They terrorized families and nations, made innumerable homes desolate, and ruined for a time cities and states. The generations now on the stage can hardly appreciate the formidable apprehensions from which their predecessors suffered, but they themselves have been relieved by the achievements of medical research and preventive medicine. This blessed preventive medicine may almost be said to have been created by the combination of bacteriological and pathological studies, which are all, of course, biological studies. Physiology has been wonderfully developed as a study of biological processes by the addition of bacteriological experimentation to

its former chemical and physical methods of research.

Public health boards have been established and equipped to perform under new laws numerous functions which had no existence until applied biology with aid from chemistry and physics indicated the desirable modes of public action. The boards, or public health commissioners, prescribe, teach and enforce rules and orders concerning personal, industrial, farm and dairy, and school hygiene, social hygiene including venereal prophylaxis for individuals and families, the preservation of foods and their protection from infection, the effects of various industries on the health of employees, the connection of syphilis with insanity and general paresis, and of gonorrhea with blindness, procure vital statistics, establish registration of births and deaths, and of cases of disease, study epidemics and infant mortality, and contend against dangerous contagious diseases by quarantines, isolation, disinfection, and the destruction of the insect and vermin carriers of disease. All these activities have been completely dependent on applied biology for their methods and processes, and have changed and developed rapidly with the progress of that science. Taken together they constitute an immense contribution to human welfare, present and future.

It is animal experimentation with the help of anesthesia and asepticism which has given mankind by far the larger part of all the exact knowledge of medicine now possessed, and promises still greater serviceableness in the future. In the service of man new studies have been made, not only of microscopic plants and animals, but of many larger creatures which live with man, such as poultry, rabbits, guinea pigs, cats, dogs, cattle, horses, mules and monkeys, and of many insects, such as flies, ticks, mosquitoes, and lice which infest the fauna and flora which surround man, or the bodies or clothes of men themselves. An immense mass of biological information on all these subjects has been accumulating during the past two generations, and is growing rapidly from year to year, as the good results of such studies become better known.

These results bear directly on the well-being and happiness of the human race, but also indirectly on the economic and commercial fortunes of the race. Through the well-directed efforts of the Rockefeller Sanitary Commission hundreds of thousands of persons in the Southern States of this country have, within the last five years, been made much more effective laborers, because relieved of the hookworm disease; and this good work is now being extended by the International Health Commission—one of the departments of the Rockefeller Foundation—to the West Indies, Central America, Ceylon, and the Straits Settlements. The work of this Commission has three divisions: (1) the Commission makes surveys of regions where hookworm disease is prevalent; (2) then it cures multitudes of sufferers by active and persistent treatment; and (3) it teaches people by the thousand how to prevent the recurrence of the disease in farming communities by using privies and wearing shoes. In the last two processes it tries—often successfully—to enlist existing public authorities and the taxing power in the work, in order to give it permanence. All this beneficent action is fruit of biological research. It would have been impossible to dig the Panama Canal, without the effective control over yellow fever and malaria which biological science has given to the race within a single generation. Two humane contributions to military efficiency during the Great War

are results of biological research applied to sanitation, one the prevention of epidemics of fever and cholera in the camps and trenches in Western Europe, and the other the quick arrest of a terrible epidemic of typhus fever in Serbia.

Let us next take account of the prospects of applied biology in the coming years. May we anticipate for it an increasing or a decreasing influence?

The progress of medical and surgical research during the past twenty years is of great promise for the future. It goes on actively in every good medical school, in many hospitals and dispensaries, and in the new institutes exclusively devoted to research. It is strongly supported by the new tendency to maintain in medical schools professorships of comparative anatomy, physiology and pathology. The importance of comparative pathology is just coming to be recognized. Inasmuch as animal experimentation, with the help of anesthesia and asepticism, is nowadays the principal means of extending the knowledge of the causes of disease and of the means of remedy and prevention, the importance of comparative studies on many species of animals, including man, has become obvious to all persons who think about the improvement of the human race and of its useful animal associates.

In regard to the treatment of contagious diseases, the story of the recent past can not but suggest hopes of even more rapid progress in the future towards the effective control of some of the worst diseases that afflict humanity. Thus, in the ten years from 1903 to 1913 syphilis was transmitted artificially to certain lower animals; the characteristic bacillus of that disease was discovered; the Wasserman test was invented, a test which enables an expert in its use to detect those cases which have no external symptoms; the value of salvarsan, as a safe destroyer of the bacillus within the human body, was demonstrated; and the bacillus was grown in pure culture outside of the body, whence resulted luetin, an important aid in the diagnosis of obscure cases; and finally the bacillus was detected in the brain of patients suffering from general paresis, and in the spinal cord of patients with locomotor ataxia. This series of discoveries and inventions has given to man a much improved control over this terrible scourge; but this control is not yet applied on an adequate scale. It remains for the future to cause this destructive disease to be early recognized, reported, and effectively dealt with. It is for state and municipal boards of health to invent and put into practise the means of contending against the spread of this horrible disease. This is a public health problem of the gravest sort. That public health authorities may succeed in the future against the horribly destructive effects of syphilis on every civilized race in the world is one of the hopes of the future, a hope inspired by the recent progress of biological science.

The progress of bio-chemistry and bacteriology has already enabled civilized governments to do much for the protection of their people from injury by foods not fit for consumption and by adulterated drugs. This is a branch of the public health service which is capable of large extension hereafter. The efficiency of the methods now used will be greatly increased; and they will be used in new fields. It is more than forty years since the Massachusetts Board of Health gave effective attention to the transportation and slaughtering of animals intended for food, an admirable piece of pioneering which brought about great improvements,

and served as a basis for further measures of defense for the community. The common use of cold-storage for meats, vegetables and fruits has lately increased the need of protection against damaged foods; and this cold-storage process is likely to be more and more used in the future—quite legitimately—for the preservation of perishable foods produced in greater quantity than can be sold at or near the time of their production. A cold-storage plant performs as to foods the function of the reservoir in an irrigation plant. Both urban and rural communities have much to hope in the future from cold-storage and irrigation; but to both these public utilities applied biological science must contribute indispensable precautions. There are climates in which extensive irrigation is liable to produce and perpetuate pestiferous insects.

One of the most favorable results of applied biology during the past fifty years is the great addition made to the means of detecting the true causes of abnormal conditions of the human body, and to the accuracy of diagnostic reasoning on both acute and chronic disorders. These new means of diagnosis and examination are in part chemical and physical, but chiefly biological. The theory and practise of asepsis are results of biological researches. Comparative anatomy, physiology and pathology all contribute largely to modern sanitation and to all the practises of boards of health for the discovery and prevention of unsanitary conditions in both urban and rural communities. Very promising examples of these useful practises are: the precautions nowadays taken against contagious disease in schools, the employment of school nurses, the inspection of school children's teeth, eyes, noses, ears and skin, the discovery in the mass of school children of the defective, the feeble-minded, and of those suffering from glandular abnormalities, particularly in the nose, mouth, and throat. The effective treatment of school children following on the detection of their disorders or defects promises much toward the better health of the coming generations. The successful use of the Schick test which enables the physician through a laboratory expert to separate the susceptible from the non-susceptible individuals who have been exposed to diphtheria, and therefore to avoid all unnecessary administrations of antitoxin, seems to open a wide prospect in the study of natural immunity. The process of improvement is not going to stop; on the contrary it will advance at an accelerated pace.

Another great field for applied biological science in the future is the contest against alcoholism and sexual vice. This is an important part of the province of social hygiene, a province which includes the philanthropic and economic treatment of the feeble-minded, the insane, the paralyzed, and the blind. The field is enormous; and its evils are intimately connected one with another; but in the whole field the means of cure and prevention have come in the main from biological research. There is every reason to expect that this great field for Christian effort will hereafter be more effectually cultivated than it has ever been.

In connection with the medical, surgical, and sanitary activities of the present day, new forms of educational effort have been instituted which are very promising for the future health and comfort of mankind. Thus, the institution of district nursing has already developed strong educational effects. The district nurse goes from house to house to treat and comfort individual patients suffering from various disorders; but in every house she also teaches the mother, sister, or some other attendant on

the sick or injured person, how to perform herself the remedial operations, how to feed the patient, and how to prevent the communication of the disease to other persons; and this teaching function of the nurse is quite as important as her curative or comforting ministrations. The social worker who follows up the out-patients of a great hospital, sees them at their homes, studies their surroundings, and gives them sympathetic counsel, has a similar teaching function, which often takes strong effect on whole families and even larger groups. Like the district nurse, she also frequently obtains family histories which are of value to students of inheritance, good or bad, and of eugenics. The same is true of the school nurse and medical inspectors who are employed by American cities in which the health department is strong and well-organized. These nurses and doctors not only detect defects and diseases in school children, but indicate to parents or friends the remedial measures that are demanded, and give much instruction to parents and guardians about keeping children well. The same educational function is performed by the dentists who are being employed in a few American cities to make periodical inspections of the teeth of school children. These large-scale examinations and teachings call for knowledge of bacteriological information and methods only recently acquired, and for skill in the use of diagnostic tools and appliances only recently invented. These new applications of biological science promise great reduction of human suffering and distress, and significant additions to average longevity and average efficiency, so soon as they come into general use.

Biological science has made possible several other kinds of widespread teaching which are certain to have beneficial effects on the productiveness of human labor, particularly in agriculture, the fundamental industry. Thus, the whole work of the International Health Commission is essentially educational. It teaches the people in hookworm disease districts by demonstration, first, that they have the disease; secondly, that it can be cured in the individual and eradicated from the community; and thirdly, that the embryos of the disease live by thousands in soil that has been befouled by an infected person, and are there ready to infect any person with whose bare, soft skin they come into contact. These demonstrations combined teach the people how the disease may be avoided in the future by an individual or by a community. As a result of this educational work, the common people and the health authorities cooperate effectively in both the work of treatment and that of prevention.

Another illustration of the broad educational processes now at work in consequence of the achievements of applied biology is to be found in the short courses given by many state universities to farmers and their grown-up sons on the principles of agriculture, the choice of seeds, and stock-raising, and in the itinerant teaching for adults now carried on by the U. S. Department of Agriculture throughout the Southern States on similar subjects. This instruction is supplemented by the offer of prizes, and the setting-up of model farms, or model acres, in great number as lessons and incitements to neighborhoods. The effects on the productiveness of American agriculture, especially in cotton and corn, are already remarkable; but the promise of these educational methods for the future is more precious still. Several colleges and universities of high standing now provide short courses which run from six to twelve weeks, some in winter and some in summer, expressly

to prepare teachers or leaders for Girls' Canning Clubs and Home Demonstration Work. These courses cover cooking, canning, sewing, market gardening, poultry husbandry, plant propagation, and rural sanitation. Their good effects have been quickly demonstrated on a large scale.

Boards of health in several American municipalities and states have lately undertaken a large work of public teaching by means of widely distributed posters and leaflets on contagia and the carriers of contagious disease. They have found themselves obliged to take this action, because they learnt by experience that the spread of contagious disease can not be prevented by enacting laws and employing inspectors to procure the execution of those laws, unless the citizens themselves cooperate actively and with intelligence in the execution of the measures which applied biology prescribes. Thus, the public at large must be taught that if streets, yards, and vacant lots of a city are kept clean, garbage is removed promptly and kept covered till removed, and the privy vault and the manure-heap are abolished, the number of flies and vermin in and about dwellings will be much reduced. Reduction in the amount of sexual vice and venereal disease can be effected by teaching parents and young people about the dangers of syphilis and gonorrhea for the individual, and their fatal effects on family happiness.

Thirdly, this immense development of biological knowledge and skill must have lessons to teach about the means of other progress, similar or contrasted.

The most important lesson which the great advance in applied biological science teaches is that the treatment of human evils and wrongs in the future should be preventive for the mass, as well as curative for the individual. This is the reason for the great change which is taking place in the profession of medicine. The main functions of that profession are to be, not the curing of individuals who are already suffering from disease, but the prevention of the spread of disease from individual to individual in the community, and the eradication or seclusion of the causes, sources, or carriers of communicable diseases. The same great change needs to be wrought in all the callings which deal with prevention of crimes and misdemeanors. Society must concern itself, not chiefly with the isolation, temporary or permanent, of the individual murderer, thief, or forger, but with the extermination or repair of the genetic, educational, or industrial defects which cause the production of criminals. Since it is often found through medical and psychological examination that the prostitute, forger, robber or poisoner is physically as well as morally defective, it is probable that biological science will in the future contribute largely to the prevention as well as cure of such bodily defects, and hence of those moral defects which in an appreciable fraction of the population result in crimes. When humane persons learn, for example, that three fifths of all the prostitutes in New York City are feeble-minded girls and women, they become interested at once in the better care and treatment under medical direction of the feeble-minded, in the means of making a trustworthy diagnosis of feeble-mindedness in children, and in preventing the feeble-minded from reproducing their like. These are all biological problems; and the progress of biological inquiry during the past fifty years is sufficient to afford the means of solving on a large scale these fundamental social problems. It is to biological science in the departments of men-

tal disease and psycho-therapy, as well as to educational theory and practise, that we must look for new methods of discipline and education in prisons, reformatories, and houses of correction. Preventive medicine and sanitary reform have shown the right way of dealing with these chronic sores in the body politic.

The interrelations of the sciences are vividly taught by the history of biology during the past eighty years. Biological science is deeply indebted to physical science for the new instruments of precision which the biologist uses in determining and recording his facts. The telephone, the x-ray, and all the electrical apparatus for recording fluent observations and making certain note of very minute portions of time and space have been invaluable additions to the resources of the biological investigator. Many of the instruments which are indispensable in botanical and zoological laboratories were not invented for biological uses, but for physical or chemical uses. The dental practise called orthodontia has profited greatly by the use of the x-rays, because the Roentgenograph exhibits the precise abnormalities in the jaws and the concealed teeth which need to be remedied. The art of photography has contributed much to biological research and biological teaching, although developed and improved more for commercial and astronomical purposes than for biological. The microscope itself and the immersion lens, tools indispensable in the study of microorganisms of all sorts, were long used in pure botany and zoology, before they became the necessary tools of applied biological science.

Again, the long series of successful applications of biological science illustrates strikingly the impossibility of drawing any fixed line of demarcation between pure and applied science, or of establishing an invariable precedence for one over the other. Sometimes an application is suddenly made of one fragment of an accumulation of knowledge which pure scientists have made without thought of any application; and sometimes a bit of knowledge successfully applied stimulates pure scientists to enter and ransack the field from which the bit came. The latter process was strikingly illustrated when the large group of the mosquitoes was studied with ardor, because two species became famous, one as the carrier of malaria, and the other of yellow fever. The anatomy and habits of the typhus fever louse had been worked out many years before that insect became known as a carrier of typhus fever. Long before salvarsan was proved valuable for killing the syphilis microorganism in the human body, a series of organic compounds derived from benzol and containing arsenic had been elaborately studied, and the means of producing them made known by chemists who had not the faintest suspicion that a safe remedy for the most destructive of contagious diseases in the human species was later to be found in a new member of the series having a reduced arsenical potency. The pure scientist often feels, and not infrequently expresses, contempt for applications of science and for the men that make them. Sometimes the seeker for valuable applications of scientific knowledge feels no interest whatever in researches of which no industrial application seems feasible or probable, and confesses publicly this lack of interest. The facts seem to be that all such feelings are narrow and irrational; that no mortal can tell how soon a practical application of a scientific truth, which seems pure in the sense that it has no present application, may be discovered; and that, on the other hand, innumerable applications are nowadays made of truths

which five years or fifty years ago seemed as remote from all human interests as the observation attributed to Thales, that a bit of amber rubbed with a piece of silk would repel pith-balls suspended by fine filaments. Yet all magnetism and electricity with their infinite applications hark back to this experiment by Thales and to Galvani's observation of twitchings in a frog's legs.

The new physiological studies of the bodily changes accompanying or produced by pain, hunger, fear, and rage already promise a new interpretation of human behavior, and therefore a new policy for human society in regard to those emotions which, from primitive times to the present day, have been the source of enormous evils to mankind. The bodily changes which in man accompany these powerful emotions have only recently been in part made known; but it has already been made out with regard to a group of these alterations in the bodily economy that they may be regarded as responses adapted to preserve the individual, and to promote his bodily welfare or his efficiency. The emotions which a man fighting experiences call into sudden and potent action the muscular and nervous forces which he needs for both offense and defense. Hunger is a highly protective sensation. Fear stimulates muscular and nervous exertion, so long as the frightened animal can flee; but, if the animal is cornered, fear turns to fury, which develops the extraordinary strength of desperation. The successful study to-day of these bodily changes and reactions prophesies a better understanding in the future of the moral forces which make for rational conduct, and of the public policies in regard to war and peace which, long pursued, may gradually affect the sum of human misery or of human happiness.

The present terrible condition of Europe and the coincident sufferings of much of the rest of the world give fresh significance to the following remarks of Louis Pasteur at the inauguration of the Pasteur Institute at Paris in 1888:

> Two contrary laws seem to be wrestling with each other nowadays—the one a law of blood and of death, ever imagining new means of destruction, and forcing nations to be constantly ready for the battle-field; the other a law of peace, work and health, ever evolving new means of delivering man from the scourges which beset him. The one seeks violent conquests; the other the relief of humanity. The latter places one human life above any victory; while the former would sacrifice hundreds and thousands of lives to the ambition of one. . . . Which of these two laws will ultimately prevail God alone knows.

The whole civilized world observes with delight that the profession of medicine, including surgery and the profession of public health and sanitation, stands out distinctly among all the intellectual callings as being steadily and universally devoted to curing the sanguinary ills of war, alleviating human sufferings from disease and folly, and extending for mankind the domain of health and happy life. These professions employ all the resources of physics, chemistry and biology for merciful ends both in peace and in war. The martial professions, on the other hand, employ many scientific discoveries and inventions, originally made for peaceful uses, as means of destruction and death. Biological science has great advantage in this respect over physical and chemical. It can not so frequently or easily be applied to evil ends.

The development of public sanitation practise during the past fifty years has taught democratic communities important lessons on the just subordination of individual interests or rights to collective interests or rights, whenever the fulfilment of individual desires imperils the collective

security. Sanitary regulations often interfere with family management, the schooling of children, the transportation and selling of perishable goods, the established practises of mining and manufacturing corporations and of small tradesmen, and even the personal habits of the private citizen. These interferences are sometimes abrupt and arbitrary. On the whole, however, this teaching has been wholesome in the freedom-loving nations, in which individualism is apt to be exaggerated, and the sense of neighborliness and social unity needs to be quickened.

The rapid development of public sanitation has also given important lessons on promptly utilizing so much as we know of applied science, but also modifying our practises rapidly whenever the subsidiary sciences effect an advance. Forty years ago the filth and fomites theory was the basis of sanitary practise. Municipal and household cleanliness are still inculcated, but the emphasis on them is no longer exclusive. Then, bacteria and other disease-producing organisms became the chief objects of interest for sanitarians, and sanitary practise was based on knowledge of these organisms, and study of the media through which they reached man, such as the air, water, the soil, dust, milk and other uncooked foods. Isolation of all cases of contagious disease was much insisted on. Isolation is still useful in many cases; but it is not regarded to-day as the one effectual defense against epidemics and the diffusion of disease. Next, insect and vermin carriers were made known, and with them came in quite a new set of sanitary practises—not a replacement but a large addition. Lastly, the contact theory of contagion, with its demonstrations that living bacteria may be carried from one person to another in minute vesicles or droplets thrown off in coughing, sneezing, or any convulsive effort, and borne on the air, has gained general acceptance. At the same time, abundant proof has been given that pathogenic bacteria and protozoa develop in the bodies of many persons without causing any recognizable symptoms. Yet the virulence of the germs these persons carry may be extreme. These recent discoveries have introduced serious difficulties into some departments of sanitary practise. The apparently healthy carrier can not be isolated; for he remains unknown. If at any time such carriers and missed cases are numerous in a given community, isolation becomes useless, if not impossible. That is the ordinary condition of most American communities in regard to tuberculosis. Hence, bacteriologists have before them a very useful piece of work in the study of human carriers of disease who are not sick. Meantime sanitary practise is obtaining sound explanations of the occasional failure of its former methods of resisting epidemics, and preventing the spread of the ordinary contagious diseases.

The principal lesson to be drawn from the experiences of sanitarians during the past fifty years is that practitioners of any useful art must be prompt at every stage of progress to make use of knowledge just attained, even if it be empirical and incomplete, and must not linger content or satisfied at any stage. This lesson is applicable in every modern industry and educational or governmental agency during either peace or war.

Biologists are now realizing that biochemistry must furnish the fundamental knowledge of the processes which incessantly go on in the healthy body, and must also provide the exact knowledge of those changes in the normal processes which lead to disease and death. The physician and the sanitarian have become accustomed to

the beneficial use of remedies and defenses which chemistry at present can neither analyze nor synthesize, such, for example, as diphtheria antitoxin; but they are aware that this condition of their art is unsatisfactory and ought not to be permanent. The animal body consists of well-known chemical substances, and its functions depend on chemical reactions. Digestion is largely a chemical process. The animal body consists of innumerable cells in great variety, each of which acts under chemical and physical laws. Hence the belief of the biologist of to-day that chemistry—analytical, structural and physical—can and will come to the aid of the science and art of medicine in the large sense, and will ultimately enable biological science to comprehend the vital processes in health and disease, and to penetrate what are now the secrets of life and death.

Charles W. Eliot

THE BUREAU OF FISHERIES

The annual report of the Commissioner of Fisheries shows that the bureau has just completed the most successful of the forty-five years of its existence. The number of fish produced and distributed was greater, and the cost of production per million less, than in any previous year. Fifty permanent hatcheries and seventy-six sub-hatcheries, auxiliaries, and egg-collecting stations have been conducted and the output during the fiscal year 1915 was over four billion young fish and eggs, an increase of more than 241,000,000 over the previous year. Plants of food fishes were made in every state and territory; fish eggs were distributed to the fish commissions of twenty-seven states; and consignments of eggs were sent to Porto Rico, Cuba, India, and Japan. The distribution of the output required over 146,000 miles of travel by the five special cars of the bureau and 491,000 miles by detached messengers. The introduction of the hump-back salmon of the Pacific coast into Maine streams, which last year was an experiment, is now a reality, as many of these fish were taken during the summer of 1915 in the Maine rivers; furthermore, ripe eggs have been taken from them—a proof of thorough acclimatization. The counter-experiment of transplanting the Atlantic lobster in Pacific waters is still in progress.

The Bureau of Fisheries has done and is doing much for the conservation and utilization of food fishes which have heretofore been wasted. Each year when the Mississippi and Illinois Rivers, with their various tributaries, overflow their banks and later recede, millions of young fish are left stranded in temporary pools or where in a short time they would perish. Rescue work is, however, undertaken by the bureau, and in 1915 over eight million valuable food fish were saved and delivered to applicants, deposited in public waters, or returned to the main rivers.

The Alaskan seals are the most valuable herd of wild animals ever owned by any government, and the Bureau of Fisheries is their custodian. The revenue to the government from the seal skins—when commercial killing is resumed—will be very large, and efforts are being made to find uses for the seal carcasses, aside from the comparatively small number required by the natives for food. The old practise of using only the skin and wasting the carcass can no longer be countenanced. The report of the special investigators who went to the Pribilof Islands in 1914 to make a thorough study of the conditions of the seal herd was submitted in January, 1915, and presents in detail a statement not alone of the condition of the seal herd, but also of the fox and reindeer herds belonging to the government, and of the natives who inhabit the seal islands. A new method of obtaining supplies for the Pribilof Islands was instituted in 1914–15, and a large saving will result therefrom.

APPOINTMENTS AND DISMISSALS AT THE UNIVERSITY OF PENNSYLVANIA

As a result of the case of Professor Scott Nearing at the University of Pennsylvania, professors of the university appointed a com-